11 Towards integrated natural resources management (INRM) in dry areas subject to land degradation: the example of the Khanasser Valley in Syria

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Introduction

The problem: land degradation and sustainability in dry areas

One of the greatest challenges currently facing humankind is the alleviation of poverty while maintaining life support systems on which we depend. Billions of people are dependent on natural resources that are often unsustainably used by poor people themselves or by other powerful stakeholders. A range of large-scale environmental problems is now threatening the long-term performance of many agricultural, forestry, livestock and fisheries systems (Campbell et al., 2003). In dryland climates, about 1,000 million ha are estimated to be degraded: 467 million ha by water erosion, 432 million ha by wind erosion, 100 million ha by chemical deterioration and 35 million ha by physical deterioration (GLASSOD approach by Oldeman et al., 1991). Recent estimates from the Millennium Assessment suggest that around 2 billion people live in the drylands (Adeel, pers. comm.).

Drylands face a number of converging trends that include:

- High population growth rates of up to 3 per cent and a demographic pattern that will result in large numbers of young people entering the job markets over the next ten to twenty years.
- Regions that are already water scarce and will be increasingly so, especially if climate change predictions are correct and the regions become hotter and drier.
- Increasing dependency on grain imports for food security.
- Increasing desertification and loss of biodiversity in some of the major centres of plant diversity.
- Increasing out-migration of males from rural areas, which will result in the loss of traditional farming systems and greater reliance on women as heads of households.
- Problems of access to international markets as a result of international trade policies and subsidies.

This creates major challenges for scientific research for development. However, natural resource sciences are not well equipped to address poverty and sustainability problems. One of the major reasons for this shortcoming is the single-disciplinary and single-scale focus of natural sciences, which fails to grapple with the issues of scale and complexity of natural resources management (NRM) problems.

The challenge

The question is how to facilitate the process of better resilience (or less vulnerability) and management of natural resources? In NRM research, the need for change has been recognized and there is a plethora of new terms to describe new approaches, such as integrated watershed management, eco-agriculture, integrated rural development, integrated conservation and development, and integrated natural resources management. However, we have failed to deliver new models for science that have significant impacts on solving NRM problems (Campbell et al., 2003).

Over the last decade, a collection of advanced tools for tackling some bottlenecks of NRM have been appearing from diverse disciplines. What is needed now is a new conceptual and overarching framework, which is able to integrate these different tools in order to cope with the complexity of real-life NRM problems. Since 1999, the Consultative Group on International Agricultural Research (CGIAR) system has joined forces with associated NARES and advanced research institutes, to develop a framework to tackle this issue. The result of this ongoing work has been labelled as the 'integrated natural resources management (INRM) framework (CGIAR, 2003 and http://www.inrm.cgiar.org/). INRM is considered as a very useful approach to tackle land degradation, because of its comprehensive nature and simplification of the inherent complexity of socio-ecological systems, that is, people are an inherent part of the ecosystem in which they live.

This chapter will clarify the concepts and approaches of the INRM framework, and apply it to the context of land degradation in dry areas. The case study applied for this purpose is Khanasser valley (northwest Syria); a site located in the transition zone between the cultivated dryland and the steppe, and it is the site chosen for the UNU-UNESCO-ICARDA Sustainable Management of Marginal Drylands (SUMAMAD) project.

Khanasser valley and its environment

Geographical location

Khanasser valley is located approximately 80 km southeast of Aleppo city. The valley is oriented in a north–south direction, between the hill ranges of the Jebel Shbeith in the east and the Jebel Al Hoss in the west (Figure11.1). The elevation of the valley is 300 to 400 m above sea level.

Major habitat

The agricultural area and the natural rangelands of the steppe (*badia*) meet in the valley. The northern part of the valley drains towards the Jabbul Salt Lake and the southern part drains towards the Adami depression in the steppe. Large flocks of sheep that graze the steppe during the winter months cross the valley in early summer on their way to greener pastures. The Jabbul Lake is a resting place for migrating birds. It has recently been named as an environmentally protected area. The diverse biophysical features and socio-economic conditions create a dynamic ecosystem in the valley and surrounding areas.

Climate

The valley has long, hot and dry summers. Rain falls from September to May, with a peak during December and January. The long term annual rainfall in Khanasser village is approximately 220 mm. Precipitation is slightly higher on the Jebel Al Hoss and reduces in southeasterly direction, towards the steppe. The rainfall displays high annual and inter-annual variability. Observed annual extremes for the last forty-five years are 93 and 393 mm. Reference evapotranspiration is approximately 2,000 mm/yr.

Geomorphology, soils

The valley is a gently undulating plain with a network of wide, dry channels. The basalt-covered hill ranges of Jebel Al Hoss and Jebel Shbeith form gently rolling plateaus, which end in well-defined steep scarps towards the valley. The slopes are covered with stones, and incised with v-shaped erosion channels.

The soils on the slopes are of variable thickness, but

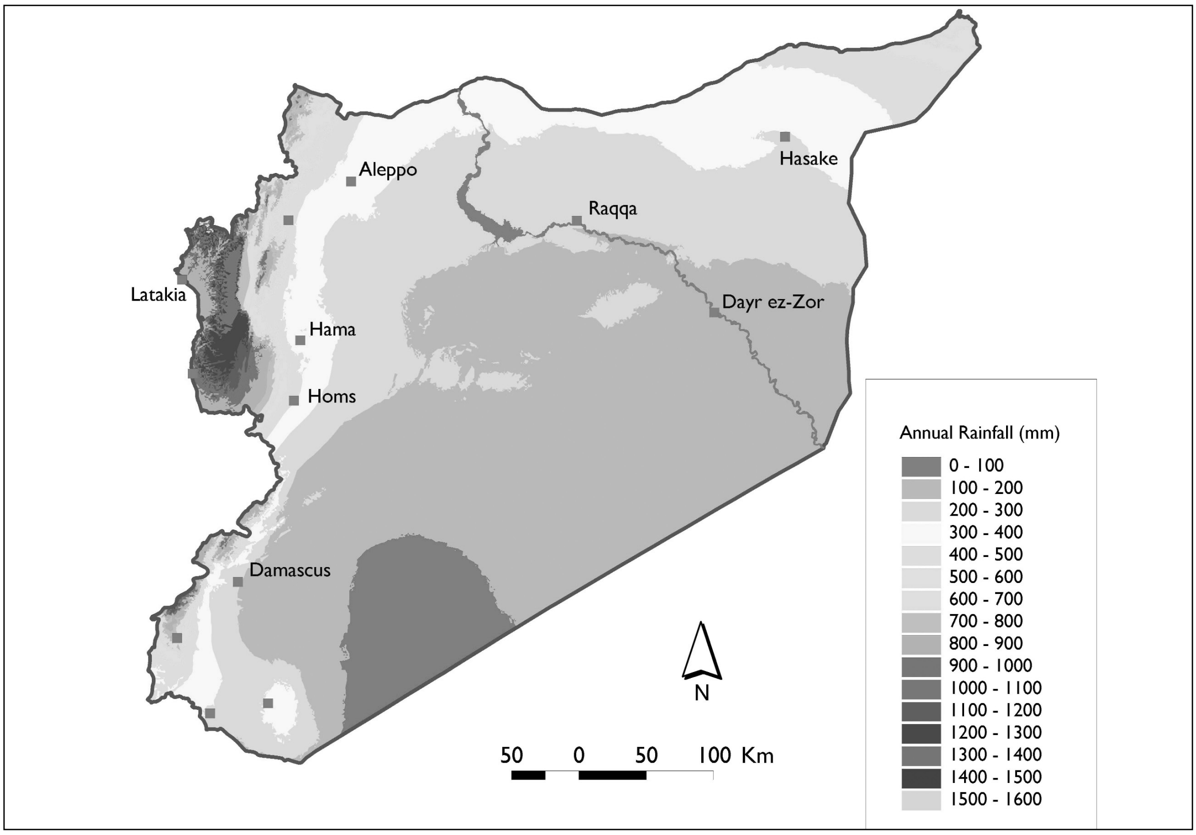

Figure 11.1. Average annual rainfall in Syria and location of study area

generally very shallow. Soil depths range from less than 1 m at the foot of the slopes to 16 m in the centre of the valley. The soils in the valley floor are fine and moderately textured dark-brown to brown calcisols, gypsisols, leptisols and cambisols. The soils of the Jebel Al Hoss and Jebel Shbeith plateaus are inceptisols. In general, the soils are well drained and have high infiltration capacity.

Major vegetation types

The flora of the Al-Hoss and Shbeit hill ranges contain 234 species, belonging to 40 families and 153 genera. Annual and biennial species are dominant in number, followed by perennials, semi-shrubs, trees (ten species) and one species of shrub (*Anagyris foetida*). The plant community on the hill slopes is dominated by *Hordeum murinum, Teucrium polium* and *Noaea mucronata*. The study area is classified as a Mediterranean–Irano–Turanian botanical region. The climax vegetation of the region was probably dry steppe–forest. Cultivation and heavy grazing has changed the vegetation. In some sites around settlements, the vegetation has been severely degraded, resulting in an extremely poor *Peganum harmala–Carex stenophlla* community, with no ability to sustain livestock.

Number of human population and families

Fifty-eight villages and communities inhabit Khanasser valley and the adjacent fringes of the Jebel Al Hoss and badia. There is a large variation among the number of resident households per village, ranging from 5 to 270. The average number of resident households was estimated at fifty per village. This number is higher in the Khanasser valley than in the steppe. The total population of the fifty-eight villages is 37,000.

Ethnic origin and composition

The population of Khanasser valley consists mainly of peasants from Bedouin origin such as the Fid'an tribe. Khanasser village has a large number of Circassians, who settled there in the beginning of last century.

Major economic activities

The majority of the population in the Khanasser valley is involved in agricultural activities. There are three main types of agricultural production systems in the valley – rain-fed farming, irrigated farming and livestock rearing. Most households practise a combination of crop production and livestock rearing. Rain-fed farming, with barley as the dominant crop, occupies the major part of the arable land. Off-farm activities are very important in providing sufficient income for the families in this resource-poor area. About 43 per cent of households in the Khanasser area have one or more members working as off-farm labour, 15 per cent of households have members working as labour in cities, and 16 per cent of households have members working outside Syria.

Major environmental/economic constraints

In most years rainfall is not sufficient to grow a rain-fed crop. A large number of wells have been installed in the valley during the last fifteen years to supplement the rainfall. However, in this dry environment the upper aquifer system receives little recharge. Consequently, the groundwater table has gone down substantially during the last two decades, and still shows a downward trend. The majority of the irrigation wells now tap groundwater that is too saline to be used for irrigation without restrictions. In the centre north of the valley, wells are affected by saltwater intrusion from the Jabbul Lake. Along the hill ranges and in the northeast and west, the water quality is good, but extremely limited, especially in summer. Most households buy drinking water from the government pipeline in the very north of the Valley. The water is brought to the houses by tractor-pulled tanks. High-intensity rainfall events occur irregularly, causing destructive floods and loss of fertile topsoil. However, the flood may also provide critical water to the soils in the valley. During the hot dry summer months, wind erosion affects the bare cropland, which is left susceptible after the stubble grazing by sheep.

The farmers have identified the following constraints:

- lack of sufficient rainfall and water for irrigation
- shortage of varieties that are resistant to diseases and drought
- financial constraints to meet customary expenses, to establish and adopt new technologies, and to purchase inputs
- widespread lack of information on appropriate technical knowledge
- unclear land property rights and policies that discourage investments, contributing to resource use conflicts, and lack of sound compensatory measures for affected groups.

Integration of environmental conservation and sustainable development

In this marginal environment the judicious and efficient use of natural resources is essential for sustaining livelihoods. Community-based planning and assistance with implementation of sustainable practices and technologies will help to improve environmental conservation. A multi-scale framework will be used to understand the interactions and dynamics of the complex resource use systems at different biophysical and socio-economic levels (see below).

Proposed activities for ensuring sustainability

The project will explore the options for the communal improvement and management of common pool resources, such as range, surface water and groundwater. Potential water-harvesting options include micro-catchments for olive and fruit trees along the hill slopes, contour ridges for shrubs and runoff strips for field crops. The development of check dams for groundwater recharge, diversions for floodwater spreading, or a small water-harvesting reservoir to provide water for supplemental irrigation could also be considered. Existing plant biodiversity will be examined for useful natural products and animal palatability. The project will also provide assistance with the implementation of options for improved agronomic management and water use efficiency, such as nutrient management, conservation tillage and the introduction of new varieties, rotations and crops, such as legumes. The approach taken will follow the INRM approach developed by the CGIAR centres (Turkelboom et al., 2002).

Defining integrated natural resources management (INRM)

'INRM is an approach that integrates research of different types of natural resources into stakeholder-driven processes of adaptive management and innovation to improve livelihoods, agro-ecosystem resilience, agricultural productivity and environmental services at community, eco-regional and global scales of intervention and impact' (Thomas, 2002). In short, INRM aims to help to solve complex real-world problems affecting natural resources in agro-ecosystems.

The main strategy to achieve this is to foster and improve the adaptive capacity and learning of all the involved stakeholders. This will not happen overnight, as conventional scientific culture has many elements that are not favourable for achieving INRM. Therefore, a change of the social organization of science and development is needed. This requires that we rethink the full spectrum of components that constitute our scientific culture (Campbell et al., 2003). There are a number of strategic directions that will facilitate this process:

- *Merging research and development*: there are persistent complaints from development agents and resource users about researchers not doing practical work. In sustainability science there is a need to have a close relationship between research and development. Researchers can no longer remain exclusively external actors, but need to engage themselves in action research in order to develop appropriate solutions together with natural resources managers (Campbell et al., 2003). We need an approach to NRM research that is driven by actual problems and based upon shared learning from real-life situations at operational scales (Maarleveld and Dangbegnon, 1999).
- *Setting up a system for adapting and learning*: the inverse relationship between the complexity of systems and our ability to make precise and yet significant statements about their behaviour suggests that NRM must be adaptive. The technological fixes of today are unlikely to be tomorrow's solutions. Rather, we need to develop a cadre of resource managers, who are able to adapt to constantly changing challenges, and we will need to nurture resource systems that are resilient to changing pressures. Therefore, integrated research is more concerned with better decision-making, increasing options and resilience, and reconciling conflicting management objectives as a foundation for better management and technological change than with producing technological packages per se (Campbell et al., 2003).
- *Balancing biophysical and socio-economic sciences*: the shift towards greater economic and political analysis in the assessment of environmental degradation may be considered as a welcome shift from geomorphology towards development studies. However, socio-economic analysis of environmental degradation may only be achieved by a thorough understanding of the nature and the importance of that degradation (Forsyth, 1992). Hudson (1995) rightly remarked that most of environmental economics is too many economists talking with other economists, but what he does not mention is that on the other side, there are too many biophysicists talking to other biophysicists. There is a need to bridge the knowledge gaps by innovative approaches, which are able to integrate several biophysical and socio-economic approaches.
- *Focusing the right type of science at the right level*: it is difficult to aggregate data from plot to field scale to landscape, watershed, eco-regional and global scales (Lal, 1998). Too often, measurements are made on one spatial and temporal scale, and the results extrapolated to another (mostly larger) scale. This is bound to produce

problems, because formulations appropriate at a given level are usually not applicable to the immediate adjoining levels (Klemeš, 1983). Each scale is therefore complementary to another scale. If the results are so scale-dependent, one wonders whether we really understand the process of land degradation, and whether our strategies for combating land degradation are really appropriate. Therefore, there is a need to make the applicable spatial and temporal scales more explicit while using scientific approaches, and to develop tools that can link analyses from different spatial and temporal scales.

So much for the INRM principles, but how do we put INRM into practice? During the fourth INRM conference at Aleppo, a deliberate effort was made to tackle this issue. This resulted in eleven 'cornerstones' that aim to operationalize INRM (Turkelboom et al., 2002). These cornerstones were applied and adapted to the context of the Khanasser valley. This resulted in a list of eighteen tools, which can be grouped into diagnostic, process and problem-solving tools (Table 11.1). It is believed that when all these tools are used at the appropriate time and place, research will be able to make a difference in NRM and will contribute to improved livelihoods. The toolbox should not be considered as a blueprint for conducting NRM. INRM requires constant improvisation and there is no single way of doing it. The toolbox should be viewed as a checklist for self-reflection and evaluation. It is suggested that each tool is at least carefully considered; otherwise, the weakest component might become a threat to the whole.

Diagnostic tools

Integrated research sites

NRM problems are usually complex, interrelated and multi-scale in nature, especially in marginal areas. Therefore, INRM research is usually conducted within a specific locality, which allows focused in-depth research on a limited area and target group, with appropriate linkages to other scales. At the same time, one should be wary that case studies do not lead to anecdotal stories, but that they generate useful approaches that can be used for larger areas (see also the section in this chapter entitled 'Scaling-out and scaling-up').

In 2000, the Khanasser valley in northwest Syria was selected by ICARDA as an integrated research site (that is, Khanasser Valley Integrated Research Site, or KVIRS) to address problems that are characteristic of the marginal dryland environments. As an integrated research site, KVIRS has dual objectives. On the one hand, the project aims to develop technologies relevant for the Khanasser area. On the other hand, KVIRS aims to develop an integrated and transferable approach to the analysis of resource degradation and the evaluation of potential resource management options, which can be applied beyond Khanasser in a spectrum of dry area environments.

Criteria used to select the site included:

- Resource degradation: rainfall is very low (about 230 mm/year) and unreliable, and resource pressure is relatively high. Different types of resource degradation are taking place, such as soil fertility depletion, overgrazing,

Table 11.1: INRM toolbox adapted for Khanasser valley integrated research site

Diagnostic tools	Tools for problem-solving and capitalizing on opportunities	Process tools
1 Integrated research site 2 Multi-level analytical framework (MLAF) 3 Livelihood, gender and community organization analysis 4 Analysis of policy, institutional and market environment 5 Analysis of natural resources status and dynamics 6 Holistic system analysis	7 Multi-level framework for interventions 8 'Plausible options' or 'best bets' 9 Decision and negotiation support tools 10 Scaling-out and scaling-up	11 Cross-disciplinary approach 12 Envisioning 13 Participatory action research (PAR) 14 Multi-stakeholder cooperation: Trust, Ownership and Commitment (TOC) 15 Capacity building of different stakeholders (INRM, organizational and technical) 16 Effective communication, coordination and facilitation strategy 17 Monitoring, evaluation and impact assessment 18 Knowledge management

water and wind erosion, salinization and over-pumping of groundwater.
- Diverse and dynamic livelihoods: livelihoods are fragile, risks multiple, and the choices available to farmers are limited by declining natural resources and regulating policies. The dominant farming enterprise is the cultivation of barley combined with extensive sheep rearing. However, alternative activities are fast gaining popularity, such as sheep fattening, cultivation of cumin, olive growing and off-farm wage labour.
- Relative easy accessibility: the study area is 180 km southeast of Aleppo.

The ultimate choice of site is always a compromise between the need to be both representative and practical. It is important therefore to specify the factors that are weighed in the final decision.

Multi-level analytical framework (MLAF)

The linkages that occur in NRM systems create the need to integrate across spatial and temporal scales. Organisms, plots, catchments and the global environment are connected. Similarly, households, villages and districts connect with international institutions. Single-disciplinary reductionist approaches are not sufficiently equipped to manage such complexity. Multi-scale approaches are necessary to capture this inter-connectivity and off-site effects, while solutions to problems will invariably require interventions at different scales (Campbell et al., 2003). In addition, by looking at the issues in an integrated way, our research results will come closer to the farmers' perspective of their livelihood and their environment.

As a result of the scarcity of resources and the prevailing risks in the dry areas, most farming systems are very integrated. The Khanasser valley is no exception to this. Therefore, a multi-level analytical framework (MLAF) was used as the diagnostic backbone, to which most of the other diagnostic tools are linked. The MLAF is subdivided into a 'spatial pillar' and a 'stakeholder pillar', all linked vertically and horizontally to different degrees. This tool can be used for analysing both technologies and natural resource use. The tool does not aim to list all possible influencing factors, but instead enables a prioritization of issues that (actually or potentially) constrain the optimum use of technologies and/or resources, and list potential solutions. In this way, research time and resources can be focused on the most strategically important issues, and interdisciplinary cooperation can be stimulated. As MLAF enables the development of a comprehensive list of potential solutions, MLAF is in fact also a problem-solving tool.

Temporal scales are especially important in dry areas, due to the unpredictability of the rainfall. Different processes take place over different time frames, giving rise to variables that operate slowly, rapidly, abruptly or cyclically. Different tools are needed to assess the dynamics of these variables, such as long-term monitoring, spatial comparisons (representing different points in time) and simulation. The MLAF can be used as a basis to map the different temporal scales.

MLAF was used to coordinate the interdisciplinary research for the proposed technologies at KVIRS. An example of MLAF application for improved management of olive orchards on hill slopes is shown in Figure 11.2. This was the result of an inter-disciplinary and multi-stakeholder assessment, which was complemented by an on-the-ground checking exercise. In the next step, the most suitable research groups to tackle the selected issues were identified and responsibilities were distributed.

Livelihood analysis

The sustainable livelihoods approach (Ellis, 2000) is a powerful tool to characterize the livelihoods strategies of rural households. This approach reveals the problems and constraints, as well as opportunities and strengths, of different land users. In addition, it identifies the economic, ecological, human and socio-cultural capital they have available, and hence their capacity to respond to change and shocks, and to maintain resilience. The ability to adapt is a vital asset in dry areas.

In Khanasser valley, households' activities tend to diversify because of the increasing uncertainty of the local socio-economic and ecological environment. The dominant livelihood types are livestock-crop farmers, pastoralists and off-farm labourers. Local people prove to be sufficiently reactive to the new ecological, market and economic challenges that threaten to affect their traditional livelihoods. However, only very few households showed a proactive attitude, which results in long-term investments in resource improvement and asset accumulation. An understanding of different livelihood strategies is very useful to target technologies and credit, to assess the impact of policy recommendations, and to link resource degradation with particular livelihood strategies.

Policy analysis

Policies and institutions have often important and sometimes unintentional impacts on land degradation and on how natural resources are used. Institutional development is particularly important in the case where common property and open access resources prevail. This is especially the case where these resources are valued differently at different levels, for example, the existence of global endangered but locally valueless

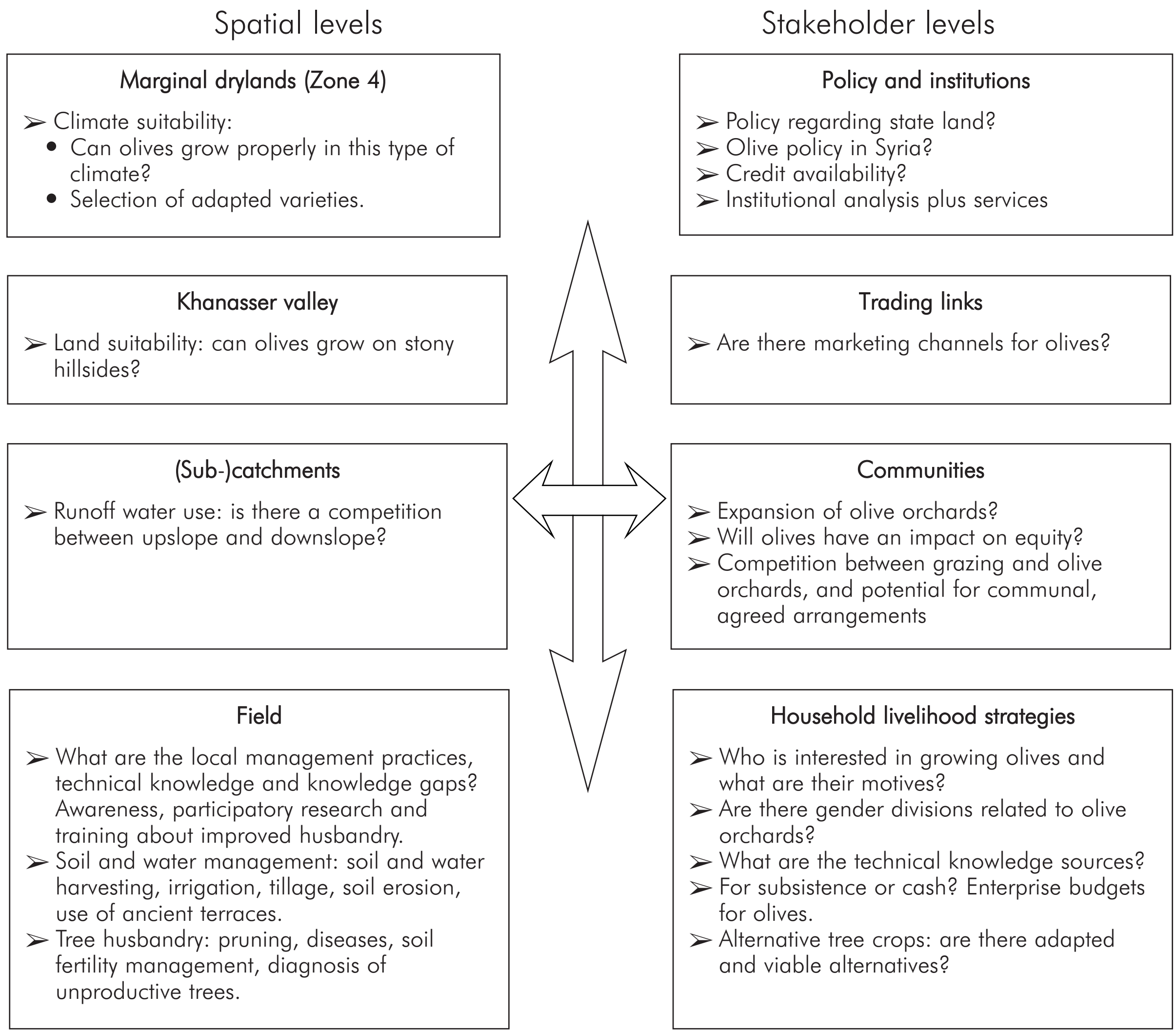

Figure 11.2 Application of the multi-level analytical framework (MLAF) to the management of olive orchards on hill slopes at Khanasser valley (potential solutions are in orange font)

species in an area of extreme poverty (Campbell et al., 2003). This implies that considerable research attention needs to be devoted to this topic.

At Khanasser valley, two policies with widespread impacts on livelihoods and NRM were identified. First, the cotton ban in Zone 4 (200 to 250 mm/year) led to the adoption of new riskier cash crops, sheep fattening, and seasonal migration for sharecropping. Second, the cultivation ban in Zone 5 (<200 mm/year) caused seasonal migration to cultivated areas for grazing or for employment opportunities. In addition, we will study the impact of policies and institutions on the adoption of new technologies, and options to improve existing policies and institutions.

Analysis of natural resources status and dynamics

There are an extensive number of tools to increase the understanding of the status and dynamics of land degradation. For the purpose of INRM, tools that can give a reasonably reliable picture in a reasonable time period are the most interesting. A few useful and commonly used NRM tools are listed here.

- *Agro-ecological characterization*: this tool can identify the biophysical limitations for agricultural production, evaluate the biophysical representativeness of the study area, and identify the potential outscaling domain from a biophysical point of view. As rainfall is a major driving factor in marginal dryland systems, analysis of rainfall distribution is very important.
- *Local perceptions and knowledge about natural resources*: close interaction with farmers is essential to increase our understanding of the natural resource dynamics, as land-users have a wealth of accumulated transmitted knowledge across generations about natural resource status, typology, degradation, sensitivity, resilience and value for livelihoods. Often this knowledge is accumulated

over many generations. In the Khanasser valley, it was found that land users could clearly identify their local soil types, the type of resource degradation taking place, its indicators, its causes, and actual and potential solutions.

- *Field assessment of land degradation processes*: although several easily available models exist these days to predict land degradation (for example, USLE for soil erosion), it is often quite risky to rely on these empirical tools as they are mostly designed for different agro-ecological conditions or a specific set of preconditions (which are often not met in the dry areas). As an alternative, it is suggested that land degradation is evaluated under field conditions by simple survey and/or measurement tools. In the case of water erosion, we are currently assessing erosion by GPS surveying and interpretation of high-resolution satellite imagery. Besides the mapping of the temporal and spatial variation, this approach also facilitates an assessment of the causes of soil erosion. Many of the causes of erosion would not have been identified by using USLE, for instance, overgrazing of the slopes by sheep and goats, up and down tillage, lack of maintenance of ancient terrace structures, and uncontrolled run-on of surface water from roads, tracks and (animal) paths.
- *Resource flow analysis*: analysis of resource flows (for example, nutrient flows, water flows) throughout and outside the focused system enables an assessment of the sustainability of resource use. Farmers can obtain a semi-quantitative picture of resource flows via participatory mapping. In a next step, monitoring and measuring in the field can assess critical flows.
- *Sensitivity and resilience analysis*: to understand the susceptibility of natural resources to degradation, it is useful to look at their sensitivity to external pressures and their resilience capacity. Sensitivity and resilience should be analysed for different ecological prototypes and for different management regimes. For some resources, threshold parameters can be relatively easily established (for instance, rangeland vegetation, groundwater, salinization, soil fertility), while for others this can be quite difficult (for example, soil erosion versus soil formation, or climate change). Based on the resource flow analysis and sensitivity and resilience analysis, resource use risk and sustainable resource use can be predicted.

Holistic system analysis

Nobody doubts that land degradation and NRM are very complex processes, and there is a major risk of getting lost in complexity. Recent theory and supporting observations suggest however that system complexity is not boundless, but has its own natural subdivisions and boundaries, and that upon further analysis, three to five key variables often drive any particular system complexity, including livelihood dynamics, degradation and/or rehabilitation of the natural resources (Gunderson and Holling, 2002). Therefore, we need to be able to identify and focus on the key drivers of a particular system, the key response variables and the key intervention points (Campbell et al., 2003).

Based on the information generated by the previous diagnostic tools and insights gained by the application of two degradation-resilience frameworks (DPSIR and 'induced innovation', EEA, 2000), a cause–effect analysis can be constructed for the Khanasser valley (although we are still at an early stage of such a holistic analysis: Figure 11.3). The driving forces are, besides the unreliable rainfall, mainly socio-economic in nature: population increase, low cash income from traditional farming system, new market opportunities (for mutton, cumin, natural products and unskilled labour), mechanization and increased mobility. These 'drivers' prompted land-users to intensify, expand and diversify their agricultural activities. The increased pressure on the natural resources and its consequent degradation had two effects: it accelerated the land-use changes, but also prompted government to impose conservation policies (especially the cotton ban, the freezing of number of wells and the cultivation ban in the steppe). Currently, we are at a stage at which land-users are coping with the effects of these policies by diversifying their agricultural production and by migration for off-farm labour. This cause–effect analysis will be further explored via simulation models. To be effective, problem-solving strategies should focus on the key drivers of the system, but if they are beyond control, then the most realistic key intervention points should be identified.

Problem-solving support tools

'Plausible promises' or 'best bets'

'Best bets' include technological, institutional and policy options, and cover most of the research of agricultural research organizations. It focuses on selecting and testing alternative technologies, under on-station or on-farm conditions. In order to link the on-farm technology development with the INRM framework, the following issues are taken into consideration:

- Participatory technology development and evaluation. Usually a constraint and opportunity analysis is conducted first to identify the priority issues.

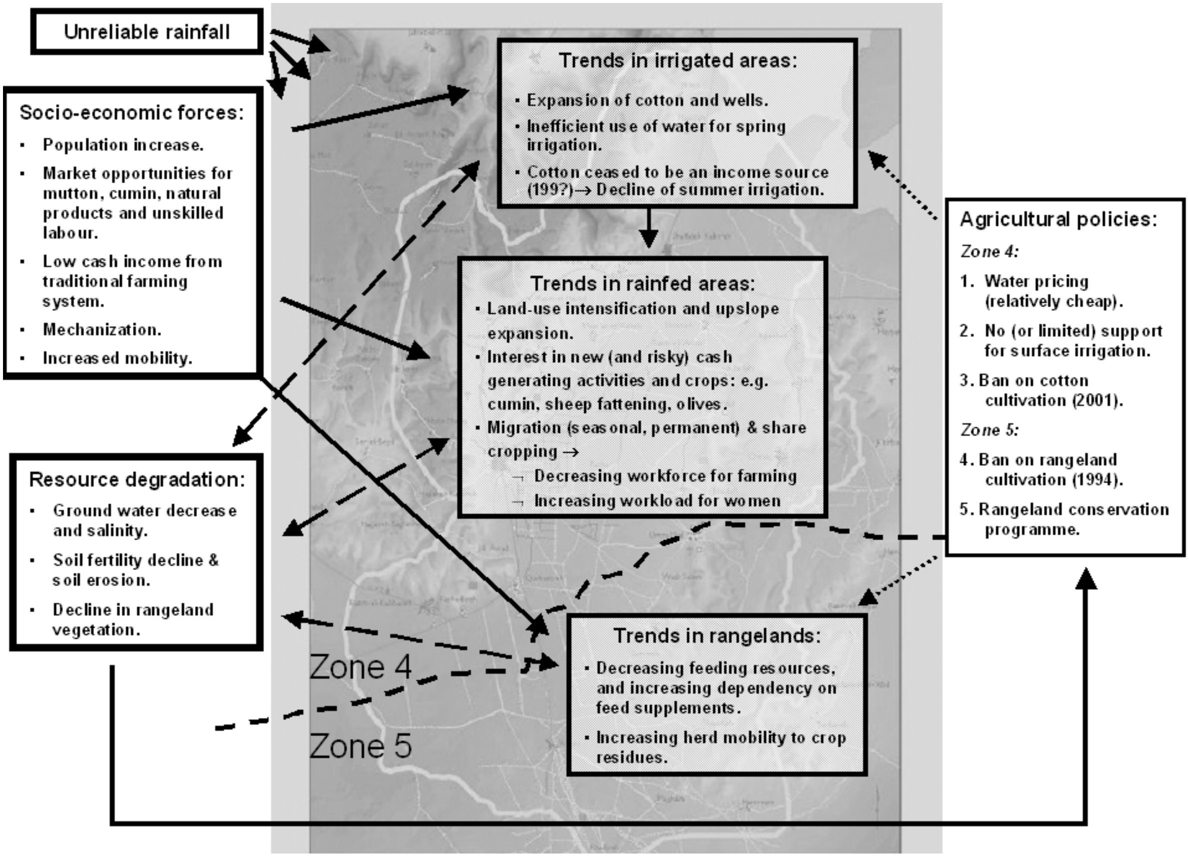

Figure 11.3: Summary of driving forces of Khanasser, and its impacts and responses
Source: modified from La Rovere et al. (2003)

Then, 'best-bets' are selected from a 'menu' derived from locally known options suggested by farmers, and options proposed by outsiders.

- Link the technology to the multi-level analytical framework. For example: monitor the environmental side-effects of technologies, consider the profitability of new technologies (enterprise budgets), and relate technologies to livelihood strategies.
- Balance between options with short-term benefits (for instance, barley varieties, vetch) and options that give medium to long-term benefits (for example, olive orchards).
- Selection of the right type of on-farm experiments (with different levels of farmers and research involvement in design and execution) based on the objectives of the experiment. 'Incentives' need to be used very carefully in on-farm experiments.

Decision and negotiation support tools

Probably nowhere as much as in the marginal dry areas are real-life decisions made on the basis of such a complex environment with only a limited number of alternatives. These can be viewed as trade-offs between competing objectives, options and externalities, and between different stakeholders and scales. Farmers analyse these factors almost unconsciously, while scientists often use models to evaluate the trade-offs between poverty, livelihoods and land degradation. The ultimate objective of research is to arrive at a transferable decision support system (DSS) that can effectively support NRM decision-making. There is an extensive toolbox for decision and negotiation support. Despite many approaches, the scientific community does not unanimously agree upon methodologies that can fully comply with INRM concepts.

For KVIRS, we aim at integrating bio-economic models with biophysical data generators, watershed modelling, and other information systems such as GIS. Because of the specific character of most problems that we are addressing at Khanasser, we are currently investigating affordable, low-data-intensive 'throw-away' models. They primarily perform *ex ante* assessment of technologies by scenario and sensitivity analysis; as well as conceptualize the system, quantify systems performance indicators, and form the basis for a final DSS and platforms for stakeholders' negotiations.

Scaling out and scaling up: going beyond the specific

Outscaling means applying the same approach in other areas. Upscaling means bringing the findings to higher levels of decision-makers (for example, local governments and policy-makers).The dissemination of conventional technological research products (for example, high-yielding crop varieties) usually follows a simple linear route from research to extension worker to farmer ('the transfer of technology' model). Sustainability science is not amenable to this sort of dissemination (Douthwaite, 2002). Scaling out and scaling up are essential strategies to increase impact beyond the specific benchmark site. Embedded in the concept of scaling out and up in NRM research is the idea that any change (technological, institutional or policy) is brought about by the formation and actions of networks of stakeholders in what is essentially a social process of communication and negotiation.This is an important departure from positivist science, and has a number of important consequences for scientists (Campbell et al., 2003):

- Researchers need to comprehend the 'impact pathways' of their outputs.
- They should plan and invest at the outset to create an enabling environment for scaling out and scaling up (including ways to come up with policy recommendations).
- It is essential that NR managers, extension officers and researchers all participate from the initiation of the research. This implies that the relationship between extension and research need to be restructured.
- Scaling out and up become part of the research process rather than a delivery mechanism for a finished product.

Tools for scaling out include evaluation of relevance of research topics beyond the research site, farmer-to-farmer extension, and similarity analysis by GIS. Tools useful for upscaling are the multi-level analytical framework (MLAF) (see the section of this chapter entitled 'Multi-level analytical framework'), multi-agent partnerships with NARES and development projects, a decentralization policy for natural resources management, and simple bulletins targeted to policy-makers.

Process tools

Cross-disciplinary approach: merging disciplinary perspectives

Disciplinary science has made, and will continue to make, major contributions to understanding, and will be at the centre of technological advance. However, to provide the context for research prioritization, integrated science will be needed (Campbell et al., 2003). Interdisciplinary research is one of the cornerstones of INRM, and its advantages have already been well discussed elsewhere.

However, interdisciplinary cooperation is not functional when everybody works with everyone on each issue. Integration always needs more consultation and takes more time then single-disciplinary activities. As such, integration is more expensive and should only be pursued when added values and synergies are expected. Somewhere in the middle, there is an optimum between integrated and single-disciplinary activities. Pragmatism suggests that we only integrate those additional components, stakeholders or scales that appear essential to solve a problem at hand. In the case of KVIRS, a key challenge was how to operationalize this type of cooperation, as there are a large number of issues to study and there are more than forty scientists involved and five participating NARES. For that purpose, logical subgroups and a coordination structure were identified. Research can be subdivided in numerous ways, but finally it was decided that it was best to organize along the most relevant farming enterprises at Khanasser, as this classification is most closely related to the farmers' reality. In addition, a secondary coordination linkage was established for natural resources with multiple uses.

Envisioning

Community envisioning is a social interactive process designed to help community members to articulate their aspirations collectively and in an organized way, and to develop a mental picture of the state to be achieved. It is an excellent tool to bring the community together for interaction, and to socially prepare a community for development planning and work. An envisioning exercise is often done by drawing the 'dream village' in an imaginable future year (between ten to twenty years from the present). While probing the 'dream village map', facilitators can elucidate farmers' hopes and aspirations. Once a common vision is established and agreed upon, it can be a powerful tool that motivates action to achieve success. Besides being a process tool, envisioning is also a diagnostic tool that can be used to identify and rank community development issues.

Participatory action research (PAR)

Action research is a well-established tool for addressing small-scale local problems. Lewin captured this idea as long ago as 1946 when he wrote, 'If you want to know how things really work, just try to change them.' However, for NRM, action research needs to be applied at different scales and to ensure participation of different stakeholders (Campbell et al., 2003). The concept of an adaptive learning cycle, in which stakeholders reflect, implement and evaluate their actions, is central to achieve science-based innovation (Röling and de Jong, 1998). However, there will be no simple cycles; rather the action research will normally be carried out as cycles within cycles. For example: short, well-defined learning cycles may give rise to opportunistic learning cycles on particularly pertinent topics, and these take place within longer-term cycles of social-ecological systems. Maintaining the linkages between the superimposed learning cycles will be crucial, but difficult (Campbell et al., 2003). This learning cycle concept is described by many authors under different labels and with different sub-steps, but the basic concept is more or less the same throughout these different types. The learning cycle usually includes the following process steps: trust building, social mobilization, diagnosis, prioritizing, selection, testing and evaluation.

At Khanasser Valley (PAR was started in 2002) a PAR training workshop was organized to initiate a shift from supply-driven to demand-driven technology development, and to increase the participation of farmers in the research process. The workshop resulted in the initiation of three farmer interest groups, concerned with olive, cumin and barley cultivation. This improved researcher–farmer interaction increased the influence farmers exert on the research agenda and enabled them to provide feedback on the proposed technologies. In addition, the process enabled an identification of expert local innovators and valuable local technical knowledge. The efficiency of participatory research will depend to a large extent on the capacities of the involved researchers and extension agents who facilitate PAR. Awareness raising and capacity building in these approaches is therefore essential. As an operational unit for technology development, farmer interest groups (FIG) were preferred rather than communities, as FIGs are more likely to involve the most relevant and interested farmers. However, to improve a common managed natural resource (for example, range or a traditional water supply system), community involvement is in most cases more appropriate.

Following the PAR training workshop a number of Farmers' Participatory Technology Evaluation Days (PTE) were organized in 2003 involving ninety farmers plus research and extension staff. The technologies examined included:

- olive production on stony hillslopes with water harvesting
- improved vetch rotations
- participatory barley breeding
- atriplex-barley intercropping
- phospho-gypsum as a soil conditioner and fertilizer
- improved cumin production.

In these events farmers were asked their opinions of the technologies that were already implemented in their fields. Specifically farmers were asked about the advantages and disadvantages of the technology, reasons for or against adoption, ways to increase diffusion, alternatives to the presented technologies, any conflicts between users, elaboration of causes and effects, and suggestions to improve the technologies. In some examples *ex post facto* SWOT (strengths, weaknesses, opportunities and threats) analyses of the technologies and evaluation day processes were conducted. Next season's experiments were also planned by the farmers and project team. Results of these PTEs will appear elsewhere.

Multi-stakeholder cooperation

Too often, research focus is often limited to the actual resource users. In reality, a diverse range of NR producers/managers/stakeholders (for example, farmers, fishers, community groups, foresters, development agencies, research organizations, traders, government officials, policy-makers) at different scales, with different political powers and with different access to science information, influence NRM outcomes. There tend to be more stakeholders when the specific resource is scarce and/or valuable. Therefore, no resource problem will be solved unless all (or most) relevant stakeholders are involved. In an ideal scenario, there will be continuous dialogue between stakeholders, and there will be little distinction between management and research. Knowledge will have to flow freely in all directions between farmers, NR managers, policy makers and researchers (Campbell et al., 2003). The fundamental key in making multi-stakeholder cooperation work includes trust, ownership and commitment (TOC). In some cases, this requires the empowering of relevant stakeholders and resolution of the conflicting interests of different stakeholders.

Capacity building of different stakeholders

Nowadays, capacity building is part of every sound research proposal. However, in most cases this capacity building is geared towards acquiring technical expertise. While this is certainly a major form of capacity building, the lack of attention to organizational and integrating skills often results in the under-performance of projects. For that purpose, capacity building for INRM should be assessed in this wider perspective.

Effective communication, coordination and facilitation strategy

Positive changes in NRM will only happen when stakeholders perceive a need for change, and external interventions will only make a difference if they contribute to the reality constructed in the minds of the stakeholders. Therefore, in order to make a real impact, changes in NRM must be owned and internalized by NR managers and other stakeholders. Change in perceptions, trust, ownership and commitment of stakeholders will only occur as a result of effective and transparent communication inside organizations and among partners (Campbell et al., 2003).

Outsiders, such as researchers, can be most effective if they have a facilitative role in this learning process. Process facilitators (persons who guide the adaptive learning cycle with multiple stakeholders) are essential to the success of INRM. They need to facilitate the integration of knowledge among stakeholders and researchers, and keep the momentum going. Furthermore, for INRM to work, a coordinator with a clear mandate to integrate all the research efforts is essential. S/he should achieve the fine balance between detailed disciplinary knowledge and cross-disciplinary knowledge, between physical and social science perspectives, between case studies and synthesis, and between positivist and constructivist traditions. Therefore, coordinators need themselves to be good facilitators (Campbell et al., 2003).

However, communication requires time and therefore it should be used efficiently. At KVIRS, different modes of communication are used depending on the objectives. Internal communication is done by meetings, task forces, joint field trips, email, intranet web pages and a shared network directory, while external communication is done by contact persons, joint field trips, exchange of reports and a field-based research assistant.

Monitoring, evaluation and impact assessment

Measurement of the impact of INRM is difficult, while it is even more complicated to establish the attribution of impacts when diverse stakeholders are involved in a complex landscape (Kuby, 1999). Conventional economic direct causal impact assessment is therefore not suitable to assess the impact in INRM. An alternative approach is proposed through assessing the improved performance of the system and the ability of the NR managers at various levels to adapt to external change. This will reflect the combined effect of research, development and other driving factors. All the involved stakeholders at the beginning of a project should decide how to measure these changes. This does not mean that the 'objective measures' are now off the agenda, but it means that researchers will be only one of the stakeholders suggesting criteria (Campbell et al., 2003).

Knowledge management

Most research projects generate a lot of unique information and knowledge. However, a common constraint faced by many projects is to write it down and to make it available in easily accessible form to interested stakeholders. In this respect, proper database management, reporting skills and the ability to translate scientific findings in simple and clear messages are essential. However, the skills for these tasks are often rare in organizations, or if available, not enough importance is given to them.

Another aspect of knowledge management is the growing recognition of informal or indigenous knowledge. Improved analytical skill is needed to integrate formal knowledge with informal knowledge. If scientists continue to operate in a simple reductionist technological world, they will fail to achieve potential pay-offs that could be obtained by linking modern science to the traditional knowledge base (Campbell et al., 2003).

While we see sustainability science being built on a social learning process, so we see NRM organizations themselves becoming more adaptive and innovative 'learning organizations', where top management promotes institutional flexibility, conditions favourable to complex learning and the integration of scientists with other stakeholders, and embraces a plurality of knowledge forms (Ashby, 2001).

Conclusions

In many land degradation research projects, diagnosis is done from a single disciplinary viewpoint, while the importance of the research process itself is often neglected. In this chapter, we try not to downplay the role of technological development and 'hard sciences', as such activities will always be at the forefront. However, the challenge is to achieve an appropriate balance between the hard and soft sciences; and between diagnostic, problem-solving and process tools. The INRM framework is considered as a useful tool to facilitate this balancing act.

Is INRM then a new way of doing business? Not really, as many research projects have already experimented with many of the discussed principles and tools. On the other hand, we can say that INRM is innovative, as it seems to be the first attempt to bring all these principles and tools together in one framework. As land degradation is such a complex societal problem with many biophysical and socio-economic interactions, we believe that INRM has much to offer to achieve sustainable livelihoods and land rehabilitation.

The 'cornerstones and toolbox of INRM' as presented here can be used as a checklist for self-reflection and evaluation. Each cornerstone needs to be carefully considered, as the weakest may become a threat to the whole. They can also be used for learning and bring experiences together thereby enhancing the communication and diffusion of better INRM.

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